ARS SPECIAL REPORT

Granular Mixed Fertilizers

ARS 22-36

January 1957

—

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

SUMMARY

The use of granular commercial fertilizer mixtures, which are less likely to cake or to stick in the drill or spreader than pulverized products, is well established and is expanding.

The fertilizer consumption survey for the fiscal year, July 1954 through June 1955--the first in which separate figures were obtained on granular products--showed that 1,331,524 tons of granular mixtures were used that year in the United States. This was 9 percent of all fertilizer mixtures.

The number of mixing plants that produce granular mixtures has almost doubled since 1954--from 80 to 150 or more.

In general, these mixtures are used at the same rates as pulverized mixtures and they are about equally efficient for crop use. Cost differences are leveling off.

The United States Department of Agriculture was among the pioneers in the development of granular fertilizers and has shared continuously in research to improve them. Today most granular products are strong enough to resist crumbling and caking, and they are resistant enough to moisture so the granules will flow freely even in damp weather.

Further improvements in granular fertilizers may be expected from research directed toward attaining more uniform distribution of nutrients among the granules and closer adjustment of phosphorus solubility and the proportions of other nutrients to meet specific nutrient requirements of different soil conditions and different crops.

Information in this report was provided by the Soil and Water Conservation Research Branch, Agricultural Research Service

GRANULAR MIXED FERTILIZERS

A progressive trend in the use of commercial fertilizers in this country is a shift from pulverized mixtures to granular mixtures which are less likely to cake or to stick in the drill or spreader. The granular mixtures are made by processes which transform pulverized mixtures into small grains or pellets.

In 1954, 80 of some 1,300 fertilizer mixing plants in the United States were equipped to granulate mixtures. Currently, the number has increased to 150 or more. Most of the large manufacturers, as well as many small ones, have installed granulating equipment. The initial outlay for equipment ranges from about $50,000 to $300,000 or higher depending upon the size of the installation and the processes used.

The importance of granular mixed fertilizers is shown in the latest survey of fertilizer consumption in the United States made by the ARS Soil and Water Conservation Research Branch. The survey reports the first separate figures on granular mixed products and covers the fiscal year, July 1954 through June 1955. In that year, 1,331,524 tons, or about 9 percent, of all fertilizer mixtures marketed in the Continental United States were in granular form. Almost 85 percent of this tonnage contained all three primary plant nutrient elements--nitrogen, phosphorus, and potassium. The remainder was made up of mixtures supplying two of the elements.

DEVELOPMENT OF GRANULAR MIXTURES

Research with plant nutrient materials in granular form in the U. S. Department of Agriculture was begun in 1922. The research program was undertaken by the fertilizer section, now within the Agricultural Research Service, in an effort to overcome two problems that were troublesome to farmers and the fertilizer industry: caking of pulverized fertilizers during storage, and their unsatisfactory drillability.

Granulation research began with single plant nutrient fertilizers. The early results were encouraging. The research workers then turned their attention to the development of mixtures which would be not merely crude mixtures of granular materials but products in which each granule contained a blend of nutrients. By 1930 they introduced a granulating technique that could be recommended for producing mixed fertilizers. Six years later in 1936, a chemical company put granular mixed fertilizers into production in the United States.

The current fast-mounting popularity of granular mixtures stems mainly from technological advances since 1950, and particularly the improvement in methods for combining ammonia--the most economic source of fertilizer nitrogen--with superphosphates in mixtures.

From the beginning of the granulation research program, the Department's soils, crops, and engineering research workers have continuously shared efforts with other research agencies and with industry to develop and improve granular fertilizers and methods of producing them.

Use of granular fertilizers has advanced much faster in some European countries than in the United States. For example, granular fertilizers constitute about 90 percent of all the mixed fertilizers in the United Kingdom. This extensive adoption of granular fertilizers is attributed partly to the fact that soils, climate, and crops are less varied than those in the United States, and fertilizer manufacturers can meet customer requirements with fewer formulations and grades.

GRANULAR FERTILIZERS COMPARED WITH PULVERIZED

Compared with pulverized fertilizers, granular fertilizers have these advantages--

* They are less likely to cake in storage.
* They flow more freely in a spreader or drill and can be more evenly distributed.
* They are not dusty, and do not blow about wastefully in windy weather.

Cost differences between granular and pulverized products are leveling out. A few years ago, granular mixtures averaged about $3 a ton more than similar pulverized products. Now, with improved processes and use of larger proportions of low-cost nitrogen materials, many granular products are priced perhaps a dollar a ton higher or no higher than pulverized.

GOALS FOR GRANULAR PRODUCTS

Describing a perfect granular fertilizer is one way of indicating quality targets toward which research and industry are aiming. One such description of six ideal properties has been drawn up by fertilizer research scientists in the ARS. Some of these specifications can probably never be fully attained, though approaches are practical. On the other hand, two of the more precisely stated goals are met or closely approached in granular mixtures now on the market.

These six ideal properties are described as follows:

1. Particle size: 10-14 mesh--screen openings 0.065 to 0.046 inch. (Such granules will pass through a screen with 10 openings to the inch but will be retained on a 14-opening screen.)

2. Particle shape: spherical.

3. Particle structures: 95 percent of the particles strong enough to resist crumbling and packing under a load equal to 100 pounds per square inch.

4. Homogeneity: each granule up to grade; that is, each contains its share of nutrients.

5. Drillability: product will stay free from lumps and maintain its original drilling rate for 1 hour when exposed to 88 percent relative humidity at 76° F.

6. Fertilizing efficiency: best possible delivery of nutrients to the growing plant.

HOW COMMERCIAL PRODUCTS MEASURE UP

Taking in turn each of the six properties described at their best, here is a summary indicating how well present granular mixed fertilizers measure up, and some of the problems that research and industry seek to overcome.

1. Particle size

A granular fertilizer in which all granules are within the most desirable size range--10-14 mesh--is so uniform a product that it would be expensive to produce for general farm use. Most granular mixtures now sold contain some granules of these sizes, but their range is wider. The most common products average fairly small granules in a 6-20 mesh range. Such particles are from 4/32 to 1/32 inch in diameter. Narrowing the range is one of the likely trends in future improvement.

Disadvantages of extremes in sizes are these:

A fine-granule product may pack and thereby defeat one of the chief purposes of granulation, which is to avoid caking.

A coarse-granule product may distribute nutrients unevenly among individual plants, as shown by this example:

If coarse 5-mesh granules are applied at a rate of 150 pounds per acre with crop rows 7 inches apart, only 11 granules will be placed per linear foot.

If medium-size 10-mesh granules are similarly applied, 154 granules will be placed per linear foot.

Size limits for granular products have not been fixed by definition.

2. Particle shape

Fertilizers consisting of smooth and perfectly shaped balls are at present impractical in farm use because of the high cost of producing them. Yet the rounder the granules, the better they will resist crumbling and packing. It is practical for commercial mixtures to contain a large proportion of fairly well-rounded granules. This is achieved in one processing method by grinding source materials fine, then moistening and rolling them in a rotating cylinder, so that as they agglomerate they are smoothed and rounded.

3. Particle structure

Considerable hardness is essential if granules are to resist crumbling and caking. About 20 years ago, scientists in the U.S. Department of Agriculture measured the strength of a number of commercial granular products and found that most of these products would remain intact under a load equal to 100 pounds per square inch. With this granule strength, products can be expected to hold up well in normal shipping and storage. Most of the granular products now marketed have this adequate strength.

4. Homogeneity

A true granulated mixture is not merely a mixture of granules of source materials. It is produced rather by pulverizing and blending source materials and then forming them into new granules, each containing the respective nutrients.

Expecting every particle in a commercial fertilizer to contain an equal proportion of nutrients would be as unrealistic as to expect granules of perfect roundness. Analyses of commercial granular mixtures have indicated that nitrogen tends to be distributed uniformly through the different-sized particles. Phosphorus, however, accumulates in the coarser particles; potassium in the finer. Analyses have indicated further than this relationship exists: The higher the nutrient content of a granular mixture, the less uniform is the nutrient distribution.

In efforts to distribute nutrients evenly the main reliance is on grinding the materials fine and blending them thoroughly. Further advances in the average uniformity of mixtures may be achieved through improvements in grinding and blending operations.

5. Drillability

If a granular fertilizer is to spread freely, it should be low in moisture at the end of processing, and it should be protected from moisture absorption until it is poured into the drillhopper.

The heating and drying in manufacturing processes help to produce firm, dry granules. Some nitrogen materials, such as ammonium nitrate and urea, are especially moisture absorbent, but because of their advantages in granulating high-analysis mixtures they are widely used. Consequently, most high-analysis granular products require high-grade moisture-resistant bags to protect them from dampness during transportation and storage. Coatings that are sometimes applied to the granules help in reducing caking.

A granular product that retains its uniform drilling rate for 1 hour at 88 percent relative humidity and 76° F. can be relied on to flow without sticking under very humid field conditions. A number of experimental and commercial granular products were recently tested for this degree of drillability at the Agricultural Research Center. Most of the high-analysis mixtures passed this test, even though some contained as much as 785 pounds of ammonium nitrate per ton.

6. Fertilizing efficiency

Measured by crop response, granular mixtures are in general as efficient as pulverized mixtures. In experimental work some differences in certain situations have been observed. These differences involve chiefly relationships between granule size of the mixture and water solubility of the phosphorus, especially when the fertilizer is used on neutral or alkaline soil.

WHEN FARMERS USE GRANULAR MIXTURES

Farmers who use granular mixtures are usually well satisfied with them. These mixtures can be used in any way that the farmer would use

pulverized mixtures. Rates of application are similar. Information regarding use of granular fertilizers follows:

Grades

Granular mixtures are available in many grades and formulations. The three grades most extensively used in 1954-55 were all high-analysis fertilizers: 12-12-12(201,985 short tons); 5-20-20(163,515 short tons); 10-10-10(102,152 short tons).

Storage

As with pulverized mixtures, care in storing bags of granular fertilizer on the farm is important to protect the material against moisture-absorption and caking. The following procedures are advisable--

* To protect contents against moisture, stack bags under cover on a board surface rather than on the ground.

* To avoid caking, stack bags not more than 10 bags high.

* To avoid bag damage, lift bags rather than drag them.

* Do not open bags until just before the fertilizer is to be used.

Equipment

The gate opening of a drill that has been used to apply pulverized fertilizers may need to be narrowed in order to distribute granular fertilizer at the desired rate per acre. The proper adjustment can be determined by placing a small amount of granular fertilizer in the drill and then measuring the rate of flow. The setting may not need to be changed during a day's drilling, since most granular fertilizers flow freely even in humid weather. However, on a damp day the rate of flow may be a little slower as work advances, especially if bags are left open in the field.

Airplane application of granular fertilizers is satisfactory for some crops, and is widely practiced by rice growers in the South.

Significance of remnant granules

A year after granular fertilizer has been deposited, remnant granules are sometimes found in upturned soil. These remnants may lead a farmer to draw mistaken conclusions:

* He may think that nutrients in the granules did not become available for plant use, or

* He may assume that considerable nutrient material is left in the granules, and that he need not fertilize again.

Actually, water-soluble nutrients generally leave the granules within a short time after the fertilizer is placed in or on the soil. If a mixture contains water-insoluble phosphorus or slowly-available nitrogen, these nutrients take longer to transfer--often becoming available during an entire growing season. In most cases, granule remnants from a past year's fertilization are largely exhausted of their nutrient value. They are not to be depended on to supply the nutrient requirements of succeeding crops.

USE OF GRANULAR FERTILIZER MIXTURES BY REGIONS

First evidence showing regional use of granular mixtures by this country's farmers has come from the ARS 1954-55 fertilizer consumption survey. Here are the quantities (short tons) of granular mixtures used in that year by regions of the United States:

New England (Conn., Maine, Mass., N.H., R.I., Vt.)	76,116
Middle Atlantic (Del., D.C., Md., N.J., N.Y., Pa., W. Va.)	133,470
South Atlantic (Fla., Ga., N.C., S.C., Va.)	12,191
East North Central (Ill., Ind., Mich., Ohio, Wis.)	449,981
West North Central (Iowa, Kans., Minn., Mo., Nebr., N. Dak., S. Dak.)	471,199
East South Central (Ala., Ky., Miss., Tenn.)	21,751
West South Central (Ark., La., Okla., Tex.)	142,682
Mountain (Ariz., Colo., Idaho, Mont., N. Mex., Nev., Utah, Wyo.)	9,903
Pacific (Calif., Oreg., Wash.)	14,231
Total	1,331,524

Farm use of granular mixed fertilizers in 1954-55 in four States exceeded 100,000 tons: Iowa, 180,112; Michigan, 139,764; Ohio, 137,871; Indiana, 103,349.

OUTLOOK FOR GRANULAR FERTILIZERS

Farm use of granular mixed fertilizers in this country is expected to continue expansion at a rapid rate, as the granular products and their production are improved.

The trend toward high-analysis fertilizers has an important bearing on the trend toward granulation. Many high-analysis products contain so much moisture-absorbent material that they can be used only in granular form.

Research and developmental work on processing can do much toward increasing the efficiency and economy of producing granular mixtures. There is need, for example, to find ways to achieve better process control of temperature and moisture relationships and to improve the design of processing equipment.

Major improvements in the granular mixtures are likely to come from research directed toward attaining more uniform distribution of nutrients among the granules and closer adjustment of phosphorus solubility and the proportions of other nutrients to meet specific nutrient requirements of different soil conditions and different crops.

Agriculture - Washington